The impact of superior segment facet-joint violation during instrumented lumbar fusion surgery

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*No grants, technical or corporate support were received in conducting this study or writing this manuscript.

This is the author's manuscript of the article published in final edited form as:
Levin, J. M., Alentado, V. J., Healy, A. T., Steinmetz, M. P., Benzel, E. C., & Mroz, T. E. (2017). Superior Segment Facet Joint Violation During Instrumented Lumbar Fusion is Associated With Higher Reoperation Rates and Diminished Improvement in Quality of Life. Clinical Spine Surgery. http://dx.doi.org/10.1097/BSD.0000000000000566

Study Design:

A retrospective cohort study of patients receiving lumbar fusion at a single tertiary care center.

Objectives:

To determine the impact of superior segment facet-joint violation (FJV) during lumbar fusion surgery on reoperation rates and quality of life (QOL).

Methods:

Patients who underwent lumbar fusion surgery between 2009 and 2013 with postoperative computed tomography (CT) imaging were included. Patients were placed in the FJV group if either of the superior segment facet-joints were compromised by the pedicle screw or rod, while patients with preserved facet-joints were placed in the control group. Demographic, perioperative, and 1-year QOL data were collected for both the FJV and control groups.

Results:

Of the 241 patients included in the study, 112 patients were found to have FJV and the remaining 129 patients were placed in the control group. One year following lumbar fusion, reoperation rates were similar between the FJV and control groups (p=0.53). At two-year follow-up, the reoperation rate in the FJV group was statistically significantly higher than in the control group (17.0% and 7.8%, respectively; p=0.02). Using a multivariate logistic regression analysis, FJV was observed to be the only independent predictor of reoperation 2 years postoperatively (p=0.03). Odds of reoperation within 2 years of operation was 2.4 times more likely for those patients with FJV. No significant difference was observed between the two groups in regards to 1-year postoperative Pain Disability Questionnaire (PDQ), Quality Adjusted Life Year (QALY), or Patient Health Questionnaire-9 (PHQ-9) scores (p=0.97, p=0.24, and p=0.79, respectively).

Conclusion:

This study is the first quantification of the impact of facet-joint violation on reoperation and quality of life. We found that FJV does not lead to any change in reoperation rate or quality of life scores 1 year after lumbar surgery. However, FJV was found to be an independent predictor for reoperation 2 years postoperatively (Odds Ratio = 2.4).

Introduction:

Lumbar fusion surgery is a common treatment for numerous lumbar spinal pathologies, increasing in annual incidence by 2.7 fold between 1998 and 2008.[1] Lumbar spinal fusion has been shown to improve neurogenic pain and quality of life (QOL). However, over time lumbar fusions may result in biomechanical alterations on unfused adjacent motion segments, leading to increased pain and worsening outcomes.[2,3] Among the numerous potential complications associated with lumbar fusion, radiographic adjacent segment degeneration (ASD) has incidence rates reported to range from 8% to as high as 100%, with symptomatic disease in 5.2% to 18.5% of cases.[4,5,6] Although it remains unclear whether this complication arises as a fusion sequelae or natural degeneration, elucidating risk factors for ASD remains a priority in the spine community.[7]

One area of interest has been the increasing evidence to support that violation of the facet-joint upon pedicle screw insertion can alter facet load-bearing capability and contribute to ASD.[8,9,10,22] Facet-joint violation (FJV) is a potential risk factor for ASD that can be controlled by the surgeon, unlike patient-associated risk factors (including age[9,10,18], female gender[9,18], bone mineral density[9,18]), and therefore can be avoided to theoretically minimize the incidence of ASD and symptomatic adjacent segment disease.[8,11,12]

To date, there is inconclusive data to clarify the extent to which facet-joint violation truly accelerates radiographic adjacent segment degeneration, if at all.[7] In the current study, we seek to illuminate the impact of superior segment facet-joint violation on reoperation rate and quality of life. We hypothesized that facet-joint violation during lumbar fusion surgery would lead to greater reoperation rates and lower quality of life scores compared to patients with preserved facet-joints.

Materials and Methods:

Patient Selection

A retrospective review was performed on all patients who underwent lumbar fusion involving any level between 2009 and 2013. Postoperative CT scans were used to evaluate facet-joint integrity following lumbar fusion; therefore, only patients with postoperative CT imaging were included within the study. Exclusion criteria included previous lumbar fusion, malignancy, and trauma. Per criteria established by Moshirfar et al[12], a facet-joint was considered violated if any of the following conditions were met: pedicle screw clearly within the facet-joint, pedicle screw within 1mm or abutting the facet-joint, pedicle screw head/connector clearly in the facet joint, pedicle screw head/connector within 1 mm or abutting the facet joint, rod clearly in the facet-joint, or rod within 1 mm or abutting the facet joint. Reoperation was defined as any type of lumbar spine revision surgery, excluding those for postoperative infection, malignancy, or trauma.

Quality of Life Data

Pre- and post-operative QOL scores including the Pain Disability Questionnaire (PDQ), Patient Health Questionnaire-9 (PHQ-9), and Quality Adjusted Life Year (QALY) were acquired. These data were prospectively collected using our institution's Knowledge Program, which captures patient-reported, disease-specific health status measures prospectively. For all measures except the QALY, a decrease in score represents improvement. Quality of life data were acquired for both groups preoperatively and at 12 months after the fusion operation. The minimum clinically important difference (MCID) used for each questionnaire 1-year postoperatively was as follows: PDQ (26), PHQ-9 (5), and QALYs (0.4).[15,16]

Statistical Analyses

All data were securely collected and managed using REDCap (Research Electronic Data Capture, Cleveland, OH, USA)[17] and analyzed with JMP 11.1.1 (2013; SAS Institute Inc, Cary, NC, USA). The facet-joint violation and control groups were

compared with the use of independent sample t tests for continuous variables, and the Fisher's exact test for categorical variables. A multivariate logistic regression analysis was used to evaluate independent predictors QOL and reoperation rate outcomes. All p values ≤0.05 were considered statistically significant.

Results:

A total of 241 patients were identified between 2008 and 2013 that met inclusion and exclusion criteria. Of these, 112 patients were found to have FJV and were therefore included in the FJV group, and the remaining 129 patients were placed in the control group. The incidence of patients with superior segment facet-joint violation in our study (112/241, 46.5%) is within the ranges seen in previously published studies.[11,12,20,21] The FJV group had a statistically significant difference in the number of female patients. Other than gender, there were no significant differences between the two groups in regards to preoperative demographics, number of levels fused, operative indications, or QOL scores. (Table 1, Table 2, Table 3)

One year following lumbar fusion, reoperation rates were similar in the FJV and control groups (5/112, 4.5% and 5/129, 3.9%, respectively; p=0.53). *At two-year follow-up,* the reoperation rate in the FJV group was statistically significantly higher than in the control group (19/112, 17.0% and 10/129, 7.8%, respectively; p=0.02) (Table 4). Using a multivariate logistic regression analysis, FJV was observed to be the only independent predictor of reoperation (p=0.03); odds of reoperation was 2.4 times more likely for those with FJV compared to those with preserved facet-joints at 2 year follow-up. (Table 5)

One year following lumbar fusion, PDQ scores showed statistically significant improvements from baseline for both the FJV (-23.7 ± 37.7, p<0.01) and control (-20.0 ± 24.3, p<0.01) groups. QALY scores also showed statistically significant improvement from baseline in both the FJV (0.14 ± 0.21, p<0.01) and the control

(0.18 ±0.24, <0.01) groups. Additionally, PHQ-9 scores showed statistically significant improvement from baseline in both the FJV (-4.1 ± 7.0, p<0.01) and control (-2.6 ± 5.9, p<0.01) groups. No significant difference was observed between the two groups in regards to 1-year postoperative PDQ, QALY, or PHQ-9 scores (p=0.97, p=0.24, p=0.79, respectively). (Table 6)

Discussion:

Facet joint violation occurs during instrumented lumbar fusion when pedicle screws are placed too medial, and becomes problematic when this is done at the superior, unfused level. Such surgical error has been increasingly recognized as a contributor to post-fusion instability and subsequent adjacent segment degeneration. In 2008, Cardoso et al[22] demonstrated this consequence in a human cadaveric study where a significant increase in range of motion was observed in adjacent segments following bilateral facet breach. While the clinical implications of FJV have been less well understood, our results support our hypothesis that facet-joint violation during pedicle screw fixation leads to a higher rate of reoperation. The clinical syndrome is poorly described in the literature, however, in our group such patients often presented with unremitting mechanical focal and correlative back pain that is worse with extension, or prolonged axial loading (i.e. standing, walking). Although no significant impact on reoperation or quality of life was demonstrated at one-year follow-up, reoperation rates in the FJV group were shown to be significantly higher at 2-year follow-up. This is consistent with the belief that radiographic and symptomatic ASD develop over the course of multiple years, perhaps accelerated by such iatrogenic facet joint violation. In a retrospective study of 65 patients, Aota et al[9] found that it took, on average, 25 months from the time of transpedicular fixation to diagnose radiographic instability. Furthermore, in a retrospective study of 125 patients, Etebar and Cahill[18] observed an average of 26.8 months until symptomatic adjacent segment disease was diagnosed. Since facet-joint violation is theorized to increase adjacent segment instability and ASD, one

would not expect to see a significant impact on reoperation or quality of life metrics 1 year postoperatively.

At two-year follow-up, the reoperation rate becomes substantially higher in the FJV group, climbing to 17.0% in this group compared to 7.8% reoperation rate in the control group (p=0.02). Using a multivariate logistic regression analysis to discover predictors of reoperation amongst our patient population, facet-joint violation prevailed as the only independent risk factor associated with reoperation. The only statistically significant difference in patient demographics between the two cohorts was gender (60% female in FJV, 48% female in control, p=0.05). ASD has been suggested to develop more commonly and rapidly in women than in men, which could have theoretically contributed to the higher reoperation rate in the FJV group.[8,9,20] However, we did not find female gender to be an independent predictor of reoperation based on the logistic regression model, thereby making this finding unlikely to be of significant clinical relevance.

In a retrospective study of 28,882 patients, Martin et al[20] observed a cumulative incidence of reoperation following lumbar fusion surgery of 10% 2 years postoperatively. Similarly, in the current study we observed a 12% cumulative incidence of reoperation 2 years postoperatively. An important point to consider is that our inclusion data, which required postoperative CT scans, could have made it more likely that our patients received reoperation. However, the similar incidence of 2-year reoperation rates between our study and that by Martin and colleagues makes this less likely. Importantly, we were able to obtain CT imaging of the lumbar spine from multiple CT indications including abdominal and pelvic CT imaging.

Neither of the groups achieved the 1-year MCID for improvement in QALYs, PDQ, or PHQ-9 scores. Within the current study, the MCID for QALYs was based on a study by Parker et al[15] of 45 patients undergoing transforaminal lumbar interbody fusion for degenerative lumbar spondylolisthesis. Within their cohort, the average preoperative QALY score was 0.37, which is considerably lower than our average

preoperative QALY score of 0.47 for the FJV group and 0.49 for the control group. The MCID for PDQ and PHQ-9 scores were based on a study by Wilson[16] that was not specific to spinal surgery, but instead examined general health outcomes of chronic pain patients. To date, no studies have yet determined MCIDs for PDQ scores and PHQ-9 scores following lumbar fusion.

This is the first clinical study that investigates the importance of FJV at unfused lumbar levels. The results highlight substantial morbidity or poor clinical outcomes following this surgical error. In addition to the existing evidence from Cardoso's[22] cadaveric study that FJV increases adjacent segment mobility, now we have observed a clinical consequence for patients with FJV. Based on this increased risk of reoperation following FJV, preserving the superior segment facet-joints by surgeons is required when placing pedicle screws. Surgeons should use pedicle screw insertion techniques that have shown lower incidence of FJV. Minimizing the risk for reoperation is of utmost importance to maximize patient health while diminishing the financial burden that reoperation likely places on the patient and the health care system.

Limitations of this study include the relatively short follow-up of 1 year for quality of life scores, and 2 years for reoperation rates. Presumably, QOL data from 1 year follow-up did not allow sufficient time to observe the potential deteriorating effects of facet-joint violation on ASD. Additionally, as with any retrospective study, selection and measurement biases may be present. Since this study was conducted at a single tertiary-care institution, the external validity may be limited to institutions with comparable patient populations and demographics. Even with these limitations, this study represents the first analysis of facet-joint violation's impact on quality of life and reoperation rates, supporting the trend to preserve superior-level facet-joints during pedicle screw fixation. Future prospective studies will aim to look at longer-term patient outcomes data in patients with and without FJV.

Conclusion:

This study represents the first quantification of the impact of facet-joint violation on reoperation rate and postoperative quality of life following instrumented lumbar fusion surgery. We found that patients who have had their superior segment facet-joint compromised during screw fixation have significantly higher rates of reoperation at 2-year follow-up compared to patients with preserved facet-joints. This avoidable complication results in substantial patients and costs absorbed by the patient, institution and health care system. These findings highlight the importance of proper starting points for pedicle screw placement. Future studies should be undertaken to determine the actual financial burden of facet-joint violation as well as an evaluation of the postoperative radiographic instability of these two differing cohorts.

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